SCIENCE:

A WEEKLY RECORD OF SCIENTIFIC PROGRESS.

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NOTICE TO SUBSCRIBERS.

We consider it due to those subscribers who have favored us with their subscriptions, previous to the publication of our club rates, that they should have the privileges of the list. They can therefore send us subscriptions for any or all of the publications named at the reduced double rates, less $4, the subscription price of "SCIENCE."

THE Report of the United States Fish Commission* for the year 1878 constitutes a volume of nearly 1,000 pages of interesting matter, and, from the economic interests involved, should command more than a passing attention from those who are desirous of having the natural resources of this country fully developed.

A large portion of the Report, relating to purely scientific work, will be highly appreciated by every naturalist. For instance, the first division of the work including researches into the character of the fishes belonging to the North American fauna, was in charge of Mr. G. Brown Goode, assisted by Dr. T. H. Bean; while it is sufficient to say that the collection and investigation of marine invertebrates was conducted by Professor A. E. Verrill, assisted by Mr. Richard Rathbun, Mr. Sanderson Smith and Mr. Warren Upham, to show the value of the researches in this direction.

Few persons will peruse this Report without feeling an obligation to Professor Spencer F. Baird for the very thorough manner in which he is carrying out the objects of this Commission; for the ground he proposes to cover would appall one of less experience.

The amount of labor involved in carrying out the work of this Commission may be estimated by a brief reference to the programme which Professor Baird has sketched for future guidance:

1st. The preparation of a series of reports upon the various groups of aquatic animals and plants of North America, especially those having relation to the wants or luxuries of mankind, to be afterwards published as monographs, with suitable illustrations.

2d. The distribution of specimens of aquatic animals and plants, not required for the National Museum, to the numerous educational and scientific establishments in the United States.

3d. A complete account of the physical character and conditions of the waters of the United States, as to chemical composition, temperature, etc., with special reference to their availability in nurturing the proper species of food fishes.

4th. A history and description of the various methods, employed in the United States, in the pursuit, capture and utilization of fishes and other aquatic animals.

5th. Statistics of the various branches of the American fisheries from the earliest dates to the present time, so as to show the development of this important ndustry and its actual condition.

6th. The establishment by the General Government, or in connection with the States, of a thoroughly reliable and exhaustive system of recording fishery statistics for the future.

7th. The bringing together in the National Museum not only of a complete collection of the aquatic animals and plants referred to, but illustrations of all apparatus or devices, used at home or abroad, in the prosecution of the fisheries.

8th. An investigation of the movements and habits of various kinds of fish, to serve as a basis for legislation, either by the General Government or by the States.

9. The arrangement of a code of regulations in respect to close seasons, and other matters of detail respecting the capture of fish.

10th. The stocking of the various waters of the United States with the fish most suited to them, either by artificial propagation or transfer, and the best apparatus and methods for accomplishing this object.

Professor Baird intends to supplement this immense amount of work by collecting and compiling statistics for the proper treatment of international questions connected with the common use, by the United States and the British Provinces, of the waters of the North Atlantic.

The volume before us bears ample proof of the power of Professor Baird and his assistants, to carry out this programme to its fullest extent, and if the work progresses at the present rate, its accomplishment will not be so far in the future as many would suppose.

*United States Commission of Fish and Fisheries, Part VI. Report of the Commissioner for 1878.

A. Inquiry into the Decrease of Food-Fishes.

B. The Propagation of Food-Fishes in the Waters of the United States. Washington Government Printing Office, 1880.

We do not propose in this notice to epitomize the report; we prefer to do more justice to the subject by presenting from time to time brief abstracts of the paper, some of which are very elaborate, occupying 160 pages of closely printed matter, and 90 illustrations.

That part of the report describing the success of the commission in propagating salmon has been anticipated by the public press, but many of the details now given are new and of great interest. Many persons in the East will be astonished at the large scale of the salmon fishery in the Western rivers, where seven to nine thousand fish are sometimes taken in one day. From one station (the St. Cloud river), fourteen millions of eggs of salmon were secured and embryonized—sufficient to keep up the supply being returned to the river, the remainder were sent East; 7,250,000 arrived in Chicago between the 3rd and 7th of October. The report states that, after supplying the home demand, 500,000 were presented to Canada, 100,000 to England, 100,000 to France, 100,000 to Holland, 250,000 to Germany and 200,000 to New Zealand.

In regard to shipments to the last named country, it is satisfactory to be able to state, that they not only arrived in perfect condition, but that by the latest advices the young fish were seen in every direction, promising to be the ancestors of a numerous progeny.

Reference is made to Professor W. O. Atwater's investigations upon the food qualities of various species of fishes, the chief facts relating to which we were able to present in an abstracted form, to the readers of "SCIENCE," a few weeks since.

Various attempts have been made to introduce live specimens of the English Sole, one of the most delicious and prolific of British fishes. The last attempt by Mr. Fred. Mather, whose skill in fish culture is acknowledged in the report, was unfortunately like the rest—a failure. Mr. Mather gives a very reasonable explanation of his want of success, and it must be admitted that he was not supplied with the necessary conveniences. During 1880, Captain Mortimer was more successful, and succeeded in placing living specimens of the Sole (*Solea vulgaris*) in New York harbor. Captain Mortimer explained to us that his apparatus consisted of a tank having a fixed cover, to which were attached two globes, the constant rolling of the vessel causing the water of the tank to pass to the globes and return, thus keeping up a constant aeration for the fish, which naturally remained at the bottom.

We reluctantly close our notice of this most valuable and interesting Report feeling that our task has been but half fulfilled. We shall, however, again take up the subject in greater detail, and present our readers with many facts of much scientific interest.

THE AMERICAN CHEMICAL SOCIETY.*

The January meeting of the above Society was held in their rooms, Monday evening, January 3, 1881, Prof. C. F. Chandler in the President's chair. The nominations of Messrs. James F. Slade, Theodore M. Hopke, A. F. Hoppick as regular, and of Mr. E. K. Dunham as associate members were made. The resignations of Prof. Ira Remsen, Prof. S. P. Sadtler and Mr. L. W. Drew, read and accepted. A motion for the reduction of the annual dues from $10 to $5 was favorably considered, and the day of meeting was changed from Thursday to Monday, so that in the future, meetings will be held on the first and third Mondays of each month, instead of on the corresponding Thursdays. There being no papers before the society, the meeting was adjourned. We add herewith a list of the officers chosen at the December meeting for the present year: President, Prof. C. F. Chandler; Vice-Presidents, A. R. Leeds, G. A. Koenig, E. R. Squibb, Charles A. Goessmann, Henry Morten, Ira Remsen; Corresponding Secretary, P. Casamajor; Recording Secretary, Albert H. Gallatin; Treasurer, W. H. Nichols; Librarian, E. Waller; Curators, W. Rupp, A. J. Rossi, A. A. Fesquet.

ON A THERMO-MAGNETIC THERMOSCOPE.

By SIR WILLIAM THOMSON.

This thermoscope is founded on the change produced in the magnetic moment of a steel magnet by change of temperature. Several different forms suggest themselves. The one which seems best adapted to give good results is to be made as follows:

1. Prepare an approximately astatic system of two thin hardened steel wires, $r\,b$, $r^1\,b^1$, each one centimetre long, one of them, $r\,b$, hung by a single silk fibre, and the other hung bifilarly from it by fibres about three centimetres long, so attached that the projections of the two on a horizontal plane shall be inclined at an angle of about .01 of a radian (or .57°) to one another.

2. Hang a very small, light mirror, bifilarly from the lower of the two wires.

3. Magnetize the two wires to very exactly equal magnetic moments in the dissimilar directions. This is easily done by a few successive trials, to make them rest as nearly as possible perpendicular to the magnetic meridian.

4. Take two pieces of equal and similar straight steel wire, well hardened, each two centimetres long, and about .04 centimetres diameter. Magnetize them equally and similarly, and mount them on a suitable frame to fulfil conditions.

5 and 6. Call them R B and $R^1\,B^1$, B and B^1 denoting the ends containing true north polarity (ordinarily marked B), and R R^1 true south (ordinarily marked red). The small letters, r, b, r^1, b^1, mark on the same plan the polarities of $r\,b$ and $r^1\,b^1$.

3. The magnets R B, $R^1\,B^1$, are to be relatively fixed in line on their frame with similar poles next one another, at a distance of about two centimetres asunder, as thus, R B . . . $B^1\,R^1$, with B B^1 = two centimetres.

6. This frame is to be mounted on a geometrical slide upon the case, within which the astatic pair, $r\,b$, $r^1\,b^1$, is hung in such a manner that the line of R B, B R bisects $r\,b$, approximately at right angles, and that R B B R may be moved by a micrometer screw through about a millimetre on each side of its central position, the line of motion being the line of R B, $B^1\,R^1$, and the "central position" being that in which B and B^1 are equi-distant from the centre of $r\,b$.

7. A lamp and scale, with proper focussing lens if the mirror is not concave, are applied to show and measure small deflections as in my mirror galvanometres and electrometer.

* Communicated by M. Benjamin, Ph. B.

8. Place the instrument with the needles approximately perpendicular to the magnetic meridian, turning it so as to bring b and b^1 to the south of the vertical plane bisecting the small angle between the projections of r b, r^1 b^1 and r, and r^1 to the north side of it.

9. By aid of the micrometer screw bring the luminous image to its middle position on the scale.

10. Cause R B, B^1 R^1 to have different temperatures. The luminous image is seen to move in such a direction as is due to r approaching the cooler, and receding from the warmer of the two deflectors B R, B^1 R^1.—*Proceedings Royal Society, Edinburgh.*

[*Continued from page* 270.]

THE UNITY OF NATURE.

By the Duke of Argyll.

IV.

ON THE LIMITS OF HUMAN KNOWLEDGE CONSIDERED WITH REFERENCE TO THE UNITY OF NATURE.

And yet, although it is to Nature in this highest and widest sense that we belong—although it is out of this fountain that we have come, and it is out of its fullness that we have received all that we have and are, men have doubted, and will doubt again, whether we can be sure of anything concerning it.

If this terrible misgiving had affected individual minds alone in moments of weariness and despair, there would have been little to say about it. Such moments may come to all of us, and the distrust which they leave behind them may be the sorest of human trials. It is no unusual result of abortive yet natural effort and of innate yet baffled curiosity. But this doubt, which is really nothing more than a morbid effect of weakness and fatigue, has been embraced as a doctrine and systematized into a philosophy. Nor can it be denied that there are some partial aspects of our knowledge in which its very elements seem to dissolve and disappear under the power of self-analysis, so that the sum of it is reduced to little more than a consciousness of ignorance. All that we know of Matter is so different from all that we are conscious of in Mind, that the relations between the two are really incomprehensible and inconceivable to us. Hence this relation constitutes a region of darkness in which it is easy to lose ourselves in an abyss of utter skepticism. What proof have we—it has been often asked—that the mental impressions we derive from objects are in any way like the truth? We know only the phenomena, not the reality of things. We are conversant with things as they appear, not with things as they are "in themselves." What proof have we that these phenomena give us any real knowledge of the truth? How, indeed, is it possible that knowledge so "relative" and so "conditioned"—relative to a mind so limited, and conditioned by senses which tell us of nothing but sensations—how can such knowledge be accepted as substantial? Is it not plain that our conceptions of Creation and of a Creator are all mere "anthropomorphism?" Is it not our own shadow that we are always chasing? Is it not a mere bigger image of ourselves to which we are always bowing down?

It is upon suggestions such as these that the Agnostic philosophy, or the philosophy of Nescience, is founded—the doctrine that, concerning all the highest problems which it both interests and concerns us most to know, we never can have any knowledge or any rational and assured belief.

It may be well to come to the consideration of this doctrine along those avenues of approach which start from the conception we have now gained of the unity of Nature.

Nothing, certainly, in the human mind is more wonderful than this—that it is conscious of its own limitations. Such consciousness would be impossible if these limitations were in their nature absolute. The bars which we feel so much, and against which we so often beat in vain, are bars which could not be felt at all unless there were something in us which seeks a wider scope. It is as if these bars were a limit of opportunity rather than a boundary of power. No absolute limitation of mental faculty ever is, or ever could be, felt by the creatures whom it affects. Of this we have abundant evidence in the lower animals, and in those lower faculties of our own nature which are of like kind to theirs. All their powers and many of our own are exerted without any sense of limitation, and this because of the very fact that the limitation of them is absolute and complete. In their own nature they admit of no larger use. The field of effort and of attainable enjoyment is, as regards them, co-extensive with the whole field in view. Nothing is seen or felt by them which may not be possessed. In such possession all exertion ends and all desire is satisfied. This is the law of every faculty subject to a limit which is absolute. In physics, the existence of any pressure is the index of a potential energy which, though it may be doing no work, is yet always capable of doing it. And so in the intellectual world, the sense of pressure and confinement is the index of powers which under other conditions are capable of doing what they cannot do at present. It is in these conditions that the barrier consists, and at least to a large extent they are external. What we feel, in short, is less an incapacity than a restraint.

So much undoubtedly is to be said as to the nature of those limitations on our mental powers of which we are conscious. And the considerations thus presented to us are of immense importance in qualifying the conclusions to be drawn from the facts of consciousness. They do not justify, although they may account for, any feeling of despair as to the ultimate accessibility of that knowledge which we so much desire. On the contrary, they suggest the idea that there is within us a Reserve of Power to some unknown and indefinite extent. It is as if we could understand indefinitely more than we can discover, if only some higher Intelligence would explain it to us.

But if it is of importance to take note of this Reserve of Power of which we are conscious in ourselves, it is at least of equal importance to estimate aright the conceptions to which we can and do attain without drawing upon this reserve at all. Not only are the bars confining us bars which we can conceive removed, but they are bars which in certain directions offer no impediment at all to a boundless range of vision. Perhaps there is no subject on which the fallacies of philosophic phraseology have led to greater errors. "That the Finite cannot comprehend the Infinite," is a proposition constantly propounded as an undoubted and all-comprehensive truth. Such truth as does belong to it seems to come from the domain of Physics, in which it represents the axiom that a part cannot be equal to the whole. From this, in the domain of Mind, it comes to represent the truth, equally undeniable, that we cannot know all that Infinity contains. But the meaning into which it is liable to pass when applied to Mind is that Man cannot conceive Infinity. And never was any proposition so commonly accepted which, in this sense, is so absolutely devoid of all foundation. Not only is Infinity conceivable by us, but it is inseparable from conceptions which are of all others the most familiar. Both the great conceptions of Space and Time are, in their very nature, infinite. We cannot conceive of either of these as subject to limitation. We cannot conceive of a moment after which there shall be no more Time, nor of a boundary beyond which there is no more Space. This means that we cannot but think of Space as infinite, and of Time as everlasting.

If these two conceptions stood alone they would be enough, for in regard to them the only incapacity under which we labor is the incapacity to conceive the Finite. For all the divisions of Space and Time with which we are so familar,—our days and months and years, and our various units of distance,—we can only think of as bits and fragments of a whole which is illimitable. But although these great conceptions of Space and Time are possibly the only conceptions to which the idea of infinity attaches as an absolute necessity of Thought, they are by no means the only conceptions to which the same idea can be attached, and probably ought to be so. The conception of Matter is one, and the conception of Force is another, to which we do not perhaps attach, as of necessity, the idea of indestructibility, or the idea of eternal existence and of infinite extension. But it is remarkable that in exact proportion as science advances, we are coming to understand that both of

these are conceptions to which the idea of infinity not only may be, but ought to be attached. That is to say, that the eternal existence of Matter and the eternal duration of Force are not only conceivable but true. Nay, it may be our ignorance alone, that makes us think we can conceive the contrary. It is possible to conceive of Space being utterly devoid of Matter, only perhaps because we are accustomed to see and to think of spaces which are indeed empty of visible substances. We can expel also the invisible substances or gases of the atmosphere, and we can speak and think of the result as a vacuum. But we know now that when air and all other terrestrial gases are gone the luminiferous medium remains; and so far as we have means of knowing, this medium is ubiquitous and omnipresent in the whole universe of Space. In like manner we are accustomed to see solid matter so dissipated as to be invisible, intangible, and wholly imperceptible; and therefore we think we can imagine matter to be really destructible. But the more we know of it the more certain we become that it cannot be destroyed, and can only be redistributed. In like manner, in regard to Force, we are accustomed to see Matter in what is called statical equilibrium—that is to say, at rest; and so perhaps, we think, we can conceive the cessation or extinction of Force. But here again the progress of research is tending more and more to attach irrevocably the idea of indestructibility—that is, of eternal existence—to that which we know as Force. The truth is, that this conception is really implicitly involved in the conception of the indestructibility of Matter. For all that we know of Matter is inseparably connected with the forces which it exerts, or which it is capable of exerting, or which are being exerted in it. The force of gravitation seems to be all-pervading, to be either an inherent power or property in every kind, or almost every kind of Matter, or else to be the result of some kind of energy which is universal and unquenchable. All bodies, however passive and inert they may seem to be under certain conditions, yet indicate by their very existence the power of those molecular forces to which the cohesion of their atoms is due. The fact is now familiar to us that the most perfect stillness and apparent rest in many forms of Matter is but the result of a balance or equilibrium maintained between forces of the most tremendous energy, which are ready to burst forth at a moment's notice, when the conditions are changed under which that balance is maintained. And this principle, which has become familiar in the case of what are called explosive substances, because of the ease and the certainty with which the balanced forces can be liberated, is a principal which really prevails in the composition of all material substances whatever; the only difference being that the energies by which their molecules are held together are so held under conditions which are more stable—conditions which it is much more more difficult to change—and conditions, therefore, which conceal from us the universal prevalence and power of Force in the constitution of the material universe. It is, therefore, distinctly the tendency of science more and more to impress us with the idea of the unlimited duration and indestructible nature both of Matter and of the energies which work in and upon it.

One of the scientific forms under which this idea is expressed is the Conservation of Energy. It affirms that though we often see moving bodies stopped in their course, and the energy with which they move apparently extinguished, no such extinction is really effected. It affirms that this energy is merely transformed into other kinds of motion, which may or may not be visible, but which, whether visible or not, do always really survive the motion which has been arrested. It affirms, in short, that Energy, like Matter, cannot be destroyed or lessened in quantity, but can only be redistributed.

As, however, the whole existing Order of Nature depends on very special distributions and concentrations of Force, this doctrine affords no ground for presuming on the permanence, or even on the prolonged continuance, of that order. Quite the contrary; for another general conception has been attained from science which at first sight appears to be a contradiction of the doctrine of "Conservation of Energy"—namely, the "Dissipation of Energy." This doctrine, however, does not affirm that Energy can be dissipated in the sense of being wholly lost or finally extinguished. It only affirms that all the existing concentrations of force are being gradually exhausted, and that the forces concerned in them are being diffused (generally in the form of Heat) more and more equally over the infinitudes of Matter and of Space.

Closely connected with, if indeed it be not a necessary part and consequence of, these conceptions of the infinity of Space and time, of Matter and of Force, is the more general concept of Causation.

It is impossibe to conceive of anything happening without a cause. Even if we could conceive the utter destruction or annihilation of any particular force or form of force, we cannot conceive of this very destruction happening except as the effect of some cause. All attempts to reduce this idea of causation to other and lower terms have been worse than futile. They have uniformly left out something which is of the very essence of the idea. The notion of "uniform antecedence" is not equivalent. "Necessary antecedence" is more near the mark. These words do indeed indicate the essential element in the idea with tolerable clearness. But like all other simple fundamental conceptions, the idea of Causation defies analysis. As, however, we cannot dissociate the idea of Causation from the idea of Force or energy, it may perhaps be said that the indestructibility or eternal duration of Force is a physical doctrine which gives strength and substance to the metaphysical concept of causation. Science may discover, and indeed has already discovered, that, as regards our application of the idea of cause, and of the correlative idea of effect, to particular cases of sequence, there is often some apparent confusion arising from the fact that the relative positions of cause and effect may be interchangeable, so that A, which at one moment appears as the cause of B, becomes at another moment the consequence of B, and not its cause. Thus Heat is very often the cause of visible motion, and visible motion is again the cause of Heat. And so of the whole cycle of physical forces, which Sir W. Grove and others have proved to be "correlated"—that is, to be so intimately related that each may in turn produce or pass into all the others. But this does not really obscure or cast any doubt upon the truth of our idea of causation. On the contrary, that idea is confirmed in receiving a new interpretation, and in the disclosure of physical facts involving the same conception. The necessity of the connection between an effect and its cause receives an unexpected confirmation when it comes to be regarded as simply the necessary passing of an energy which is universal and indestructible from one form of action into another. Heat becomes the cause of Light because it is the same energy working in a special medium. Conversely Light becomes the cause of Heat, because again the same energy passes into another medium and there produces a different effect. And so all the so-called "correlated forces" may be interchangeably the cause or the consequence of each other, according to the order of time in which the changes of form are seen. This, however, does not confound, but only illustrates the ineradicable conviction that for all such changes there must be a cause. It may be perfectly true that all these correlated forces can be ideally reduced to different "forms of motion;" but motion itself is inconceivable except as existing in Matter, and as the result of some moving force. Every difference of direction in motion or of form in Matter implies a change, and we can conceive no change without a cause—that is to say, apart from the operation of some condition without which that change would not have been.

The same ultimate conceptions, and no other, appear to constitute all the truth that is to be found in a favorite doctrine among the cultivators of physical science— the so-called "Law of Continuity." This phrase is indeed often used with such looseness of meaning that it is extremely difficult to understand the primary signification attached to it. One common definition, or rather one common illustration, of this law is said to be that Nature does nothing suddenly—nothing "per saltum." Of course this can only be accepted under some metaphorical or transcendental meaning. In Nature there is such a thing as a flash of lightning, and this is generally recognized as sufficiently sudden. A great many other exertions of electric force are of similar rapidity. The action of chemical affinity is always rapid. and very often even instantaneous. Yet these are among the most common and the most powerful factors in the me-

chanism of Nature. They have the most intimate connection with the phenomena of Life, and in these the profoundest changes are often determined in moments of time. For many purposes to which this so-called "Law of Continuity" is often applied in argument no idler dogma was ever invented in the schools. There is a common superstition that this so-called law negatives the possibility, for example, of the sudden appearance of new forms of Life. What it does negative, however, is not appearances which are sudden, but only appearances which have been unprepared. Innumerable things may come to be,—in a moment—in the twinkling of an eye. But nothing can come to be without a long, even if it be a secret, history. The "Law of Continuity" is, therefore, a phrase of ambiguous meaning; but at the bottom of it there lies the true and invincible conviction that for every change, however sudden—for every "leap," however wide—there has always been a long chain of predetermining causes, and that even the most tremendous bursts of energy and the most sudden exhibitions of force have all been slowly and silently prepared. In this sense the Law of Continuity is nothing but the idea of Causation. It is founded on the necesary duration which we cannot but attribute to the existence of Force, and this appears to be the only truth which the Law of Continuity represents.

When now we consider the place in the whole system of our knowledge which is occupied by these great fundamental conceptions of Time and Space, and of Matter and of Force, and when we consider that we cannot even think of any one of these realities as capable of coming to an end, we may well be assured that, whatever may be the limits of the human mind, they certainly do not prevent us from apprehending infinity. On the contrary, it would rather appear that this apprehension is the invariable and necessary result of every investigation of nature.

It is indeed of the highest importance to observe that some of these conceptions, especially the indestructibility of Matter and of Force, belong to the domain of science. That is to say, the systematic examination of natural phenomena has given them distinctness and a consistency which they never possessed before. As now accepted and defined, they are the result of direct experiment. And yet, strictly speaking, all that experiment can do is to prove that in all cases in which either Matter or Force seems to be destroyed, no such destruction has taken place. Here then we have a very limited and imperfect amount of "experience" giving rise to an infinite conception. But it is another of the suggestions of the Agnostic philosophy that this can never be a legitimate result. Nevertheless, as a matter of fact, these conceptions have been reached. They are now universally accepted and taught as truths lying at the foundation of every branch of natural science—at once the beginning and the end of every physical investigation. They are not what are ordinarily called "laws." They stand on much higher ground. They stand behind and before every law, whether that word be taken to mean simply an observed order of facts, or some particular force to which that order is due, or some combinations of force for the discharge of function, or some abstract definition of observed phenomena such as the "laws of motion." All these, though they may be "invariable" so far as we can see, carry with them no character of universal or necessary truth—no conviction that they are and must be true in all places and for all time. There is no existing order—no present combinations of Matter or of Force—which we cannot conceive coming to an end. But when that end is come we cannot conceive but that something must remain,—if it be nothing else than that by which the ending was brought about or, as it were, the raw materials of the creation which, has passed away. That this conception, when once suggested and clearly apprehended, cannot be eradicated, is one of the most indisputable facts of instructed consciousness. That no possible amount of mere external observation or experiment can cover the infinitude of the conclusion is also unquestionably true. But if "experience" is to be upheld as in any sense the ground and basis of all our knowledge, it must be understood as embracing the most important of all kinds of experience in the study of Nature —the experience we have of the laws of Mind. It is one of the most certain of those laws, that in proportion as the powers of the understanding are well developed, and are prepared by previous training for the interpretation of natural facts, there is no relation whatever between the time occupied in the observation of phenomena and the breadth or sweep of the conclusions which may be arrived at from them. A single glance, lasting not above a moment of time, may awaken the recognition of truths as wide as the universe and as everlasting as Time itself. Nay, it has often happened in the history of science that such recognitions of general truths have been reached by no other kind of observation than that of the mind becoming conscious of its own innate perceptions. Conceptions of this nature have perpetually gone before experiment—have suggested it, guided it—and have received nothing more than corroboration from it. I do not say that these conceptions have been reached without any process. But the process has been to a large extent as unconscious as that by which we see the light. I do not say they have been reached without "experience," even in that narrow sense in which it means the observation of external things. But the experience has been nothing more than the act of living in the world, and of breathing in it, and of looking round upon it. These conceptions have come to Man because he is a Being in harmony with surrounding Nature. The human mind has opened to them as a bud opens to the sun and air. So true is this, that when reasons have been given for the conclusions thus arrived at—these reasons have often been quite erroneous. Nothing in the history of philosophy is more curious than the close correspondence between many ideas enunciated by the ancients as the result of the speculation, and some, at least, of the ideas now prevalent as the result of science. It is true that the ancients expressed them vaguely, associated them with other conceptions which are wide of the truth, and quoted in support of them illustrations which are often childish. Nevertheless the fact remains that they had attained to some central truths, however obscured the perception may have been by ignorance of the more precise and accurate analogies by which they can be best explained, and which only the process of observation has revealed. "They had in some way grasped," says Mr. Balfour Stewart,* "the idea of the essential unrest and energy of things. They had also the idea of small particles or atoms; and finally of a medium of some sort, so that they were not wholly ignorant of the most profound and deeply seated of the principles of the material universe." There is but one explanation of this, but it is all-sufficient. It is that the mind of Man is a part, and one at least of the highest parts, of the system of the universe—the result of mechanism most suited to the purpose of catching and translating into thought the light of truth as embodied in surrounding Nature.

We have seen that the foundations of all conscious reasoning are to be found in certain propositions which we call self-evident. That is to say, in propositions the truth of which is intuitively perceived. We have seen, too, as a general law affecting all manifestations of Life or Mind, even in its very lowest forms, that instinctive or intuitional perceptions are the guide and index of other and larger truths which lie entirely beyond the range of the perception or intuition which is immediately concerned. This law holds good quite as much of the higher intuitions which are peculiar to Man as of the mere intuitions of sensation which are common to him and to the animals beneath him. The lowest savage does many things by mere instinct which contain implicitly truths of a very abstract nature—truths of which, as such, he has not the remotest conception, and which in the present undeveloped condition of his faculties it would be impossible to explain to him. Thus, when he goes into the forest to cut a branch fit for being made into a bow, or when he goes to the marsh to cut a reed fit for being made into an arrow, and when in doing so he cuts them off the proper length by measuring them by the bows and arrows which he already has, in this simple operation he is acting on the abstract and most fruitful truth that "things equal to the same thing are equal to one another." This is one of the axioms which lie at the basis of all mathematical demonstration. But as a general, universal, and necessary truth the savage knows nothing of it—as little as he knows of the wonderful consequences to which it will some day lead his children or descendants. So in like

* "Conservation of Energy," p. 135.

manner when the savage designs, as he often does, most ingenious traps for the capture of his prey, and so baits them as to attract the animals he desires to catch, he is counting first on the constancy and uniformity of physical causation, and, secondly, on the profoundly different action of the motives which determine the conduct of creatures having Life and Will. But of neither of these as general truths does he know anything, and of one of them at least, not even the greatest philosophers have reached the full depth of meaning. Nevertheless, it would be a great error to suppose that the savage, because he has no conception of the general truth involved in his conduct, has been guided in that conduct by anything in the nature of chance or accident. His intuitions have been right, and have involved so much perception of truth as is necessary to carry him along the little way he requires to travel, because the mind in which those intuitions lie is a product and a part of Nature—a product and part of that great system of things which is held together by laws intelligible to Mind—laws which the human mind has been constructed to feel even when it cannot clearly see. Moreover, when these laws come to be clearly seen, they are seen only because the mind has organs adjusted to the perception of them, and because it finds in its own mechanism corresponding sequences of thought.

It was the work of a great German metaphysician towards the close of the last century to discriminate and define more systematically than had been done before some at least of those higher elements of thought which, over and above the mere perception of external things, the mind thus contributes out of its own structure to the fabric of knowledge. In doing this he did immortal service—proving that when men talked of "experience" being the source of knowledge, they forgot that the whole process of experience presupposes the action of innate laws of thought, without which experience can neither gather its facts nor reach their interpretation. "Experience," as Kant most truly said, is nothing but a "synthesis of intuitions"—a building up or putting together of conceptions which the access of external Nature finds ready to be awakened in the mind. The whole of this process is determined by the mind's own laws—a process in which even observation of outward fact must take its place according to principles of arrangement in which alone all explanations of them consists, and out of which any understanding them is impossible.

And yet this great fact of a large part of our knowledge—and that the most important part—coming to us out of the very furniture and constitution of the mind itself, has been so expressed and presented in the language of philosophy as rather to undermine than to establish our confidence in the certainty of knowledge. For if the mind is so spoken of and represented as to suggest the idea of something apart from the general system of Nature, and if its laws of thought are looked upon as "forms" or molds into which, by some artificial arrangement or by some mechanical necessity, everything from outside must be squeezed and made to fit—then it will naturally occur to us to doubt whether conceptions cut out and manufactured under such conditions can be any trustworthy representation of the truth. Such, unfortunately, has been the mode of representation adopted by many philosophers—and such accordingly has been the result of their teaching. This is the great source of error in every form of the Idealistic philosophy, but it is a source of error which can be perfectly eliminated, leaving untouched and undoubted the large body of truths which has made that philosophy attractive to so many powerful minds. We have only to take care that in expressing those truths we do not use metaphors which are misleading. We have only to remember that we must regard the mind and the laws of its operation in the light of that most assured truth—the Unity of Nature. The mind has no "molds" which have not themselves been molded on the realities of the universe—no "forms" which it did not receive as a part and a consequence of a unity with the rest of Nature. Its conceptions are not manufactured; they are developed. They are not made; they simply grow. The order of the laws of thought under which it renders intelligible to itself all the phenomena of the universe, is not an order which it invents, but an order which it simply feels and sees. And this "vision and faculty divine" is a necessary consequence of its congenital relations with the whole system of Nature—from being bone of its bone—flesh of its flesh—from breathing its atmosphere, from living in its light, and from having with it a thousand points of contact visible and invisible, more than we can number or understand.

And yet so subtle are the suggestions of the human spirit in disparagement of its own powers—so near and ever present to us is that region which belongs to the unsatisfied Reserve of Power—that the very fact of our knowledge arising out of our organic relations with the rest of Nature has been seized upon as only casting new discredit on all that we seem to know. Because all our knowledge arises out of these relations, therefore, it is said, all our knowledge of things must be itself relative; and relative knowledge is not knowledge of "things in themselves." Such is the argument of metaphysicians—an argument repeated with singular unanimity by philosophers of almost every school of thought. By some it has been made the basis of religious proof. By some it has been made the basis of a reasoned skepticism. By some it has been used simply to foil attacks upon belief. The real truth is that it is an argument useless for any purpose whatever, because it is not itself true. The distinction between knowledge of things in their relations, and knowledge of things "in themselves," is a distinction without a meaning. In metaphysics the assertion that we can never attain to any knowledge of things in themselves does not mean simply that we know things only in a few relations out of many. It does not mean even that there may be and probably are a great many relations which we have not faculties enabling us to conceive. All this is quite true, and a most important truth. But the metaphysical distinction is quite different. It affirms that if we knew things in every one of the relations that affect them, we should still be no nearer than before to a knowledge of "things themselves." "It is proper to observe," says Sir W. Hamilton, "that had we faculties equal in number to all the possible modes of existence, whether of mind or matter, still would our knowledge of mind or matter be only relative. If material existence could exhibit ten thousand phenomena,—if we possessed ten thousand senses to apprehend these ten thousand phenomena of material existence, of existence absolutely and in itself we should then be as ignorant as we are at present."* The conception here that there is something to be known about things in which they are not presented as in any relation to anything else. It affirms that there are certain ultimate entities in Nature to which all phenomena are due, and yet which can be thought of as having no relation to these phenomena, or to ourselves, or to any other existence whatever. Now as the very idea of knowledge consists in the perception of relations, this affirmation is, in the purest sense of the word, nonsense—that is to say, it is a series of words which have either no meaning at all or a meaning which is self-contradictory. It belongs to the class of propositions which throw just discredit on metaphysics—mere verbal propositions, pretending to deal with conceptions which are no conceptions at all, but empty sounds. The "unconditioned," we are told, "is unthinkable;" but words which are unthinkable had better be also unspeakable, or at least unspoken. It is altogether untrue that we are compelled to believe in the existence of anything which is "unconditioned"—in Matter with no qualities—in Minds with no character—in a God with no attributes. Even the metaphysicians who dwell on this distinction between the Relative and Unconditioned admit that it is one to which no idea can be attached. Yet, in spite of this admission, they proceed to found many inferences upon it, as if it had an intelligible meaning. Those who have not been accustomed to metaphysical literature could hardly believe the flagrant unreason which is common on this subject. It cannot be better illustrated than by quoting the words in which this favorite doctrine is expressed by Sir William Hamilton. Speaking of our knowledge of Matter he says: "It is a name for something known—for that which appears to us under the forms of extension, solidity, divisibility, figure, motion, roughness, smoothness, color, heat, cold," etc. "But," he goes on to say, "as these phenomena appear only in conjunction, we are compelled by the constitution of our nature to think them conjoined in and by something; and as they

* "Lectures," vol. i. p. 145.

are phenomena, we cannot think them the phenomena of nothing, but must regard them as the properties or qualities of something that is extended, figured, etc. But this something, absolutely and in itself—*i. e.*, considered apart from its phenomena—is to us as Zero. It is only in its qualities, only in its effects, in its relative or phenomenal existence, that it is cognizable or conceivable; and it is only by a law of thought which compels us to think something absolute and unknown, as the basis or condition of the relative and known, that this something obtains a kind of incomprehensible reality to us." The argument here is that because phenomena are and must be the "properties or qualities of something else," therefore we are "compelled to think" of that something as having an existence separable from any relation to its own qualities and properties, and that this something acquires from this reasoning a "kind of incomprehensible reality!" There is no such law of thought. There is no such necessity of thinking nonsense as is here alleged. All that we are compelled to think is that the ultimate constitution of Matter, and the ultimate source of its relations to our own organism, are unknown, and are probably inaccessible to us. But this is a very different conception from that which affirms that if we did know or could know these ultimate truths, we should find in them anything standing absolutely alone and unrelated to other existences in the Universe.

It is, however, so important that we should define to ourselves as clearly as we can the nature of the limitations which affect our knowledge, and the real inferences which are to be derived from the consciousness we have of them, that it may be well to examine these dicta of metaphysicians in the light of specific instances. It becomes all the more important to do so, when we observe that the language in which these dicta are expressed generally implies that knowledge which is "only relative" is less genuine or less absolutely true than some other kind of knowledge which is not explained, except that it must be knowledge of that which has no relation to the mind.

There is a sense (and it is the only sense in which the words have any meaning) in which we are all accustomed to say that we know a thing "in itself," when we have found out, for example, its origin, or its structure, or its chemical composition as distinguished from its more superficial aspects. If a new substance were offered to us as food, and if we examined its appearance to the eye, and felt its consistency to the touch, and smelt its odor, and finally tasted it, we should then know as much about it as these various senses could tell us. Other senses, or other forms of sensation, might soon add their own several contributions to our knowledge, and we might discover that this substance had deleterious effects upon the human organism. This would be knowing, perhaps, by far the most important things that are to be known about it. But we should certainly like to know more, and we should probably consider that we had found out what it was "in itself," when we had discovered farther, for example, that it was the fruit of a tree. Chemistry might next inform us of the analysis of the fruit, and might exhibit some alkaloid to which its peculiar properties and its peculiar effects upon the body are due. This, again, we should certainly consider as knowing what it is "in itself." But other questions respecting it would remain behind. How the tree can extract this alkaloid from the inorganic elements of the soil, and how, when so extracted, it should have such and such peculiar effects upon the animal body; these, and similar questions, we may ask, and probably we shall ask in vain. But there is nothing in the inaccessibility of this knowledge to suggest that we are absolutely incapable of understanding the answer if it were explained to us. On the contrary, the disposition we have to put such questions raises a strong presumption that the answer would be one capable of that assimilation by our intellectual nature in which all understanding of anything consists. There is nothing in the series of phenomena which this substance has exhibited to us—nothing in the question which they raise which can even suggest the idea that all these relations which we have traced, or any others which may remain behind, are the result of something which can be thought of or conceived as neither a cause nor a consequence—but solitary and unrelated. On the contrary, all that remains unexplained is the nature and cause of its relations—its relations on the one hand to the elements out of which vegetable vitality has combined it, and its relations on the other hand to the still higher vitality which it threatens to destroy. Its place in the unity of Nature is the ultimate object of our search, and this unity is essentially a unity of relations, and of nothing else. That unity everywhere proclaims the truth that there is nothing in the wide universe which is unrelated to the rest.

Let us take another example. Until modern science had established its methods of physical investigation, Light and Sound were known as sensations only. That is to say, they were known in terms of the mental impressions which they immediately produce upon us, and in no other terms whatever. There was no proof that in these sensations we had any knowledge "in themselves" of the external agencies which produce them. But now all this is changed. Science has discovered what these two agencies are "in themselves;" —that is to say, it has defined them under aspects which are totally distinct from seeing or hearing, and is able to describe them in terms addressed to wholly different faculties of conception. Both Light and Sound are in the nature of undulatory movements in elastic media—to which undulations our organs of sight and hearing are respectively adjusted or "attuned." In these organs, by virtue of that adjustment or attuning, these same undulations are "translated" into the sensations which we know. It thus appears that the facts as described to us in this language of sensation are the true equivalent of the facts as described in the very different language of intellectual analysis. The eye is now understood to be an apparatus for enabling the mind instantaneously to appreciate differences of motion which are of almost inconceivable minuteness. The pleasure we derive from the harmonies of color and of sound, although mere sensations, do correctly represent the movement of undulations in a definite order; whilst those other sensations which we know as discords represent the actual clashing and disorder of interfering waves. In breathing the healthy air of physical discoveries such as these, although the limitations of our knowledge continually haunt us, we gain nevertheless a triumphant sense of its certainty and of its truth. Not only are the mental impressions, which our organs have been so constructed as to convey, a true interpretation of external facts, that the conclusions we draw as to their origin and their source, and as to the guarantee we have for the accuracy of our conceptions, are placed on the firmest of all foundations. The mirror into which we look is a true mirror, reflecting accurately and with infinite fineness the realities of Nature. And this great lesson is being repeated in every new discovery, and in every new application of an old one. Every reduction of phenomena to ascertained measures of force; every application of mathematical proof to theoretical conceptions; every detection of identical operations in diverse departments of Nature; every subjection of material agencies to the service of mankind; every confirmation of knowledge acquired through one sense by the evidence of another—every one of these operations adds to the verifications of science, confirms our reasonable trust in the faculties we possess and assures us that the knowledge we acquire by the careful use of these is a real and substantial knowledge of the truth.

If now we examine the kind of knowledge respecting Light and Sound which recent discoveries have revealed to us, as compared with the knowledge which we had of them before these discoveries were made, we shall find out that there is an important difference. The knowledge which we had before was the simple and elementary knowledge of sensation. As compared with that knowledge, the new knowledge we have acquired respecting light and sound, is a knowledge of these things "in themselves." Such is the language in which we should naturally express our sense of that difference, and in so expressing it we should be expressing an important truth. The newer knowledge is a higher knowledge than the older and simpler knowledge which we had before. And why? Wherein does this higher quality of the new knowledge consist? Is it not in the very fact that the new knowledge is the perception of a higher kind of relation than that which we had perceived before? There is no difference between the two kinds of knowledge in respect to the mere abstract character of relativity. The old was as relative as the new; and the new is as relative as the old. Before the new discoveries sound

was known to come from sonorous bodies, and light was known to come from luminous bodies. This was a relation—but a relation of the vaguest and most general kind. As compared with this vague relation the new relation under which we know them is knowledge of a more definite and of a higher kind. Light and Sound we now know to be words or ideas representing not merely any one thing or any two things, but especially a relation of adjustment between a number of things. In this adjustment Light and Sound, as known to sense do "in themselves" consist. Sound becomes known to us as the attunement between certain aerial pulsations and the auditory apparatus. Light becomes known to us as a similar or analogous attunement between the ethereal pulsations and the optic apparatus. Sound in this sense is not the aerial waves "in themselves," but in their relation to the ear. Light is not the ethereal undulations "in themselves," but in their relation to the eye.

It is only when these come into contact with a pre-arranged machinery that they become what we know and speak of as Light and Sound. This conception, therefore, is found to represent and express a pure relation; and it is a conception higher than the one we had before, not because it is either less or more relative, but because its relativity is to a higher faculty of the intellect or the understanding.

And, indeed, when we come to think of it, we see that all kinds of knowledge must take their place and rank according to this order of precedence. For, as all knowledge consists in the establishment of relations between external facts and the various faculties of the mind, the highest knowledge must always be that in which such relations are established with those intellectual powers which are of the highest kind. Hence we have a strictly scientific basis of classification for arranging the three great subjects of all human inquiry—the What, the How, and the Whence or Why. These are steps in an ascending series. What things are, how they come to be, and for what purpose they are intended in the whole system of Nature—these are the questions, each rising above the other, which correspond to the order and the rank of our own faculties in the value and importance of their work.

It is the result of this analysis to establish that, even if it were true that there could be anything in the Universe existing out of relation with other things around it, or if it were conceivable that there could be any knowledge of things as they so exist, it would be no higher knowledge, but infinitely lower knowledge than that which we actually possess. It could at the best be only knowledge of the "What," and that, too, in the lowest conceivable form—knowledge of the barest, driest, nakedest existence, without value or significance of any kind. And further, it results from the same analysis that the relativity of human knowledge, instead of casting any doubt upon its authenticity, is the very characteristic which guarantees its reality and its truth. It results further, that the depth and completeness of that knowledge depends on the degree in which it brings the facts of Nature into relation with the highest faculties of Mind.

It must be so if Man is part of the great system of things in which he lives. It must be so, especially if in being part of it, he is also the highest visible part of it—the product of its "laws" (as regards his own little corner of the Universe) the consummation of its history.

Nor can there be any doubt as to what are the supreme faculties of the human mind. The power of initiating changes in the order of Nature, and of shaping them from the highest motives to the noblest ends—this, in general terms, may be said to include or to involve them all. They are based upon the ultimate and irresolvable power of Will, with such freedom as belongs to it; upon the faculty of understanding the use of means to ends, and upon the Moral Sense which recognizes the law of righteousness and the ultimate Authority on which it rests. If the Universe or any part of it is ever to be really understood by us—if anything in the nature of an explanation is ever to be reached concerning the system of things in which we live, these are the perceptive powers to which the information must be given—these are the faculties to which the explanation must be addressed. When we de-desire to know the nature of things "in themselves," we desire to know the highest of their relations which are conceivable to us: we desire, in the words of Bishop Butler, to know "the Author, the cause and the end of them."

ASTRONOMY.

ELEMENTS OF SWIFT'S COMET.

COMPUTED BY PROFESSOR E. FRISBY, U. S. NAVAL OBSERVATORY, WASHINGTON.

[Communicated by Rear Admiral John Ro'gers, U. S. Navy, Superintendent.]

To the Editor of SCIENCE:

The following elements of Swift's comet have been computed by Professor Frisby from three observations made with the Transit Circle at Washington by Professor Eastman on the nights of October 25th, November 7th and 20th, with these results. No assumptions about any periodic time have been made.

Epoch—Perihelion passage.
November 7.77568d, Wash. M. T.

$$\left.\begin{array}{rrrl} \Omega = & 296^\circ & 48' & 19''.9 \\ \pi = & 42 & 59 & 15\ .8 \\ \phi = & 42 & 26 & 48\ .5 \\ i = & 5 & 30 & 35\ .9 \\ \log a = & \multicolumn{3}{l}{0\ .517002} \\ \log \mu = & \multicolumn{3}{l}{2''.774504} \end{array}\right\} \text{Mean equinox 1880.0}$$

The comet approached very near to the Earth on November 20th, its distance being less than $\frac{1}{7}$th of the Sun's distance. We have for the dates given:

	log r	log Δ
October 25	0.035328	9.221510
November 7	0.029018	9.141693
" 20	0.034558	9.119295

Its perihelion distance thus appears to be a little greater than the distance of the Earth; and its aphelion lies just beyond Jupiter's orbit. The periodic time from these observations being about 2178d., or a little less than 6 years, there can be no doubt that the preiodic time of about 5½ years is the correct one.

U. S. NAVAL OBSERVATORY, WASHINGTON, D. C.,
January 6, 1881.

THE SOLAR ECLIPSE.—The last contact of the partial solar eclipse on the morning of December 31, 1880, was seen at Harvard College Observatory under quite favorable circumstances. The mean of six observations by as many different observers gives:

Last contact, December 30, 21h. 13m. 3s. Cambridge Mean Time.

At the United States Naval Observatory the last contact was observed by Prof. Hall, with a comet seeker of 4in. aperture and magnifying power of 19 diameters, as follows:

Last contact, December 30, 20h. 32m. 36s. Washington Mean Time. Owing to the extremely low temperature (11 degrees below zero, Fahr.) at Washington, the images were very poor and the observation somewhat uncertain. W. C. W.

NEW YORK MICROSCOPICAL SOCIETY.

The annual meeting for the selection of officers for the year 1881, took place on the 31st ultimo, when the following officers were elected: President, Romyn Hitchcock; Vice-President, E. C. Bogart; Recording Secretary, W. H. Mead; Corresponding Secretary, Benjamin Braman; Treasurer, W. C. Hubbard; Curator, Dr. Deems.

This Society will shortly give a public *conversazione,* when a variety of interesting objects will be exhibited, and an opportunity afforded to Microscopists to examine many new forms of Microscope stands which have been recently produced. Those who desire to assist or be present on this occasion should address Professor Romyn Hitchcock, 53 Maiden Lane, N. Y.

EPHEMERIS OF SWIFT'S COMET.

The following is a continuation of Mr. Upton's Ephemeris, which he has corrected by observations made at Washington up to Jan. 7, 1881. Mr. Wendell, at Harvard College Observatory, obtained an observation for position on Jan. 3, and Prof. Hall is of the opinion that the comet can be followed without great difficulty, even after the present moon.

EPHEMERIS—WASHINGTON MIDNIGHT.

1881	R. A. h. m. s.	Dec. ° ′
Jan. 11	6 0 26	+26 57.4
13	6 2 52	26 23.6
15	6 5 15	25 52 2
17	6 7 34	25 22.9
19	6 9 51	24 55 6
21	6 12 7	24 30.2
23	6 14 21	24 6.5
25	6 16 35	23 44 3
27	6 18 48	23 23 5
29	6 21 2	23 4 0
31	6 23 16	+22 45.8

WASHINGTON, D. C., January 8, 1881. W. C. W.

ECLIPSE OF THE SUN.

The partial eclipse of the Sun which occurred on December 31, 1880, was observed with the spectroscope at my private observatory.

For this purpose, the instrument was so adjusted that it would present its slit radially to the limb of the Moon; and the C line was placed in the centre of the field, in order to see any solar protuberance that might be at the place of observation.

At about the time of greatest obscuration, the slit was directed on the Moon's limb outside of the Sun, at some distance from its western cusp. Although the limb of the Moon was absolutely invisible in the telescope outside of the Sun, as ascertained before, yet, the presence of the satellite was immediately made known in the spectroscope, where it gave a very distinct broad grayish band spectrum, running along the brighter spectrum of the vicinity of the Sun.

The phenomenon became more apparent the nearer the slit was moved towards the Sun, and it vanished from sight when it was at a distance estimated at 3 or 4 minutes from the solar limb.

As the eclipse drew nearer the end, the phenomenon became less and less conspicuous on the western side, and at about 9 o'clock it had almost entirely ceased.

An unsuccessful attempt was made to observe the phenomenon taking place at the point of last contact, when the Moon's limb left that of the Sun. For this purpose the slit of the instrument was placed radially to the point of emergence. But either because no phenomenon was perceptible, or perhaps rather because the slit was not exactly at the right place, nothing was seen.

If the dull spectrum obtained when the slit of the spectroscope was placed in the immediate vicinity of the Sun was due only to the solar light, which is reflected by our atmosphere, it is plain that this spectrum would have been as bright on the Moon as it was outside of it, since the terrestrial atmosphere lies as necessarily between the observer and the Moon as it does between us and the Sun, and therefore no dark band spectrum could have been seen. But as it was visible, it must be inferred that besides the spectrum given off by the solar light reflected by our atmosphere, there must have been some other light, either emitted or reflected, coming from a point situated beyond the Moon, which reinforced the spectrum given off by the solar light reflected by our atmosphere.

This light, undoubtedly, can be no other than that of the solar atmosphere, or Corona, visible during total eclipses of the Sun.

If this reasoning is sound, the conclusions to be drawn from these observations are that the Corona, or at least traces of it, was visible during this partial eclipse, and that it was much brighter in the northwest equatorial regions than it was in the East; and, furthermore, that in the West it was less and less brilliant as it was observed northward, until it was completely invisible in the northern regions of the Sun. L. TROUVELOT.

CAMBRIDGE, *December* 31, 1880.

JUPITER.

OBSERVATIONS OF THE GREAT RED SPOT.

Having devoted most of my observing time this year to the phenomenæ of Jupiter, I would respectfully submit a few observations of the great red spot, situated in the south temperate zone of the planet.

Up to December 14, (the last observation on account of cloudy weather,) I have observed forty transits of the red spot across the central meridian. Thirty-four of these have been complete transits, *i. e.*, the preceding end the middle and the following end being observed.

The following table contains twenty-nine of these transits and is given in Greenwich mean time. The first, third and fifth columns give the observed time of passage of the preceding end, the middle and the following end of the spot.

Columns two, four and six, contain the times by which each portion of the spot preceded the passage of an assumed meridian that has a rotation period of $9^h\ 55^m\ 27.^s08$ (an ephemeris of the transits of this meridian has been published at intervals in the *English Mechanic*, by Herr A. Marth of the Royal Astronomical Society, and is corrected for parallax, velocity of light and phase).

The last column (7) contains the duration of transit in minutes, that is, the interval between the passage of the *P* and *F ends.*

TRANSIT OF JUPITER'S GREAT RED SPOT.

	1	2	3	4	5	6	7
GREENWICH m. t. 1880.	Transit of P. end.	Preceding Ass'd Meridian.	Transit of Middle.	Preceding Ass'd Meridian.	Transit of F. End.	Preceding Ass'd Meridian	Duration of Transit.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*m.*	*m.*
August 30	17 21.9	1 34.7	17 45.4	1 11.2	18 11.4	45.2	49.5
September 9	15 38 9	1 26.6	16 02.4	1 03.1	16 26.4	39.1	47.5
" 14	------	-----	15 14.4	55.4	------	----	----
" 16	16 19.4	1 27.2	16 49.4	57.2	17 11.4	35.2	52.0
" 18	18 01.4	1 22.0	18 24.9	58.5	18 50.4	33.0	49.0
" 25	18 45.0	1 19.5	19 09.7	54.9	19 32.3	32.2	47.3
" 28	16 15.5	1 16.5	16 40.1	51.9	17 03.9	28.1	48 4
" 30	17 51.5	1 17.3	18 19.5	49.3	18 44.0	24.9	52.5
October 1	13 44.3	1 15.2	14 12.0	47.5	14 39.0	20.5	54.7
" 6	12 48.7	1 15.1	13 16.7	47.1	13 44.7	19.1	56.0
" 7	18 32.2	1 17.7	19 00.2	49.7	19 27.0	22.9	54.8
" 10	16 00.7	1 16.7	16 26.7	50.7	16 55.7	21.7	55.0
" 13	13 31.2	1 13.8	13 57.2	47.8	14 23.0	22.0	51.8
" 20	14 16.0	1 10.5	14 40.0	46.5	15 03.8	22.7	47.8
" 2[illegible]	------	-----	16 17.2	46.2	------	----	----
November 1	14 04.9	1 08 1	14 34.7	38.3	14 56.5	16.5	51.6
" 4	------	-----	12 01.0	39.9	12 25.2	15.7	----
" 8	14 52.0	1 03.3	15 16.7	38.5	15 43.1	12.2	51.1
" 10	16 30.2	1 02.2	16 55.0	37.5	17 19.4	13.0	49.2
" 11	12 20.1	1 03.2	12 42.9	40.4	13 11.2	12.1	51.1
" 18	13 03.2	1 02.8	13 28.0	40.0	13 54.8	11.4	51.4
" 20	14 44.2	59.1	15 08.7	34.6	15 34.0	9.4	49.8
" 22	16 25.9	54.8	16 47.2	31.5	17 15.5	5.2	49.6
" 23	12 18.2	53.4	12 39.5	32.1	13 06.2	5.4	48.0
December 2	14 42.9	49.5	15 02.2	30.2	15 27.9	4.5	45.0
" 5	12 12.9	48.1	12 32.2	28.8	12 57.2	3.8	44.3
" 7	13 46.5	52.0	14 10.0	28.5	------	----	----
" 9	15 24.9	50.2	15 49.3	25.8	16 12.7	2.4	47.8
" 14	14 33.2	49.3	14 56.0	26.5	15 21.4	1.1	48.2

The above table shows that the red spot varies considerably in length. These variations are shown in the last column, marked "Duration of Transit."

Assuming that the red spots period of rotation is 9^h 55^m $37^s.065$—which is probably very near the truth—we find that in one minute of time $0^\circ.604$ of the surface will pass a given meridian. Multiplying the minutes in the last, or column 7, by .604, we get the following table of lengths in longitude on the surface of Jupiter. The first nine are taken from a table of eleven transits observed by me previous to August 30, and published in *English Mechanic*, No. 809:

July 10, 1880	40°.45	Oct. 6, 1880	33°.82
" 17, "	26 .58	" 7, "	33 .10
" 24, "	27 .78	" 10, "	33 .22
" 29, "	32 .62	" 13, "	31 .29
" 31, "	30 .20	" 20, "	28 .87
Aug. 13, "	33 .82	Nov. 1, "	31 .17
" 16, "	23 .86	" 8, "	30 .86
" 17, "	27 .78	" 10, "	29 .72
" 23, "	27 .78	" 11, "	30 .86
" 30, "	29 .90	" 18, "	31 .05
Sept. 9, "	28 .75	" 20, "	30 .08
" 16, "	31 41	" 22, "	29 .96
" 18, "	29 .60	" 23, "	28 .99
" 25, "	28 .57	Dec. 2, "	27 .18
" 28, "	29 .23	" 5, "	26 .76
" 30, "	31 71	" 9, "	28 .87
Oct. 1, "	33 .04	" 14, "	29 .11

On July 10 the spot had a narrow strip running from its preceding end. To this is due the great length of the spot on that date. This does not indicate the true length of the spot proper, but as it was a portion of the spot, or continuation, I give the length on that date.

It must not be supposed that, because I have carried the lengths to two places in the decimals, I consider the length accurate to that degree, for the observations have been entirely eye estimations, yet they were very carefully made. I think a variation of one degree in the length of the spot would be easily detected, and probably a less amount, as the agreement between most of the figures is too close and regular to attribute to chance. As my method of observing may be of interest, I will give an example from my note book. First: I watch closely the first end of the spot, and imagine a line dropped from it to the equatorial belt and observe when this is central, for it is much easier to halve the straight edge-like line of the equatorial belt than to halve the disk on a parallel with the spots centre, because the spot itself being on one side of the meridian biases our judgment to a certain extent, while the clean edge of the equatorial belt is free of any obstacle to interfere with our judgment. Second: I compare the spaces between the limbs of the planet and the ends of the spot, when these are seen to be equal, of course the spots centre is in transit. For determining the transit of the following end, the same method as that in determining the preceding end is followed. At the observation of each part of the spot there exists for a short while a period of uncertainty. The beginning of this uncertainty I indicate by *u*, noting the time. In a minute or so I feel sure the time of true phase has arrived, this is noted by *t*, with its time. Shortly, I am certain the phase has passed, this I note as *c*, with its time. The mean of the three is taken for the true phase.

The following is an observation of the transit of the red spot on October 13, 1880, Nashville, *mt*, taken from my note book.

		h. m.	*h. m.*	
P	*u*	7 40		
	t	7 44	7 44	
	c	7 48		
	u	8 07	*h. m.*	*h m.*
M	*t*	8 10	8 10	**8 09.9**
	c	8 13		
	u	8 32.5	*h. m.*	
F	*t*	8 36.5	8 35.8	
	c	8 38.5		

The mean of the nine observations agrees with the observed middle transit to .1 m. This close agreement cannot, of course, be expected often. However, they generally agree to within a few fractions of a minute. In no case have I allowed myself to know beforehand what time any phase *should* occur, as this might influence the observations.

The variations in length of the spot are not only shown by the duration of transit, but are sensible to an observing eye. At each observation I estimate its length, comparing it with the breadth of the disk on the same parallel of latitude. These comparisons show changes in its length, as they vary from 1-3.5 to ⅓ the breadth of the disk, but it is generally the slightest bit less than one-third.

The variations in breadth are compared with the great equatorial band, but unfortunately this is a standard that probably varies itself. The spot's breadth is generally slightly less than ½ the width of the equatorial belt, sometimes it is probably fully half as broad as the belt, but I have never seen it broader than that.

Changes in the width of the space between the south edge of the equatorial belt and the north edge of the spot, are more readily detected, as the space can be easily compared with the breadth of the spot. This space is generally equal to ⅓ the spot's breadth, yet it is sometimes nearly one-half as broad as the spot. I have seen it diminished to one-sixth. These changes are due either to a swelling out of the spot or a broadening of the equatorial belt. It is more likely due to changes in the spot. I have on several occasions estimated that the distance between the southern edge of the equatorial band and the southern edge of the spot was about equal to one-third the distance from the south pole to the equatorial belt.

There are sometimes slight changes in the general form of the spot; at times the ends are blunt or rounded, again they are cigar shaped. One end has been seen rounded while the other was very much pointed. The sides are at times a little flattened, but are generally slightly rounded. On July 24 the south-side was curved or convex, while the north-side was somewhat flattened. It is sometimes long and lanky and then again it is fat and "chubby"—neither of these have been carried to extremes. Faint continuations, or trails, have been visible, sometimes from one end and then from the other. These have on several occasions been seen trailing from both ends at once, but are not always seen without close looking. At times the spot is a deep solid brick color; then again it is lightish red and pale. I have never, for certain, seen any detail on the surface of the spot, but I have sometimes thought that there *was* detail but just too indefinite for my aperture. The outline of the spot is always clean—no diffusion.

These observations are from notes and sketches which I have made this year with a 5-inch Byrne refractor.

E. E. BARNARD.

NASHVILLE, TENN., *December* 27, 1880.

NOTE.—The motions of the spots on Jupiter, in an article by me in "SCIENCE" No. 24, are referred to an assumed rotation period of 9h. 55m. 27.08s., which should have been stated in that article. E. E. B.

PENNULE'S COMET.

The following position of this comet was obtained by ring micrometer, on December 30, 1880, 7h. 01.2 m., Nashville m. t.:

R. A. 19h. 55m. 38.5s.

Dec. + 18° 52′ 39.6″

It is several minutes in diameter and very brightly condensed. E. E. BARNARD.

NASHVILLE, Tenn., Jan. 2, '81.

THE CAMBRIDGE OBSERVATORY.

The Annual Report of Prof. Pickering, Director of Harvard College Observatory, shows that the Observatory has been in a most prosperous condition during the past year, and if the same financial support is extended to it in the future that has been so generously offered in the past few years, it will be enabled to retain its place, inferior to no other Observatory in the country. The work carried on at the Cambridge Observatory consists of observations with the 15in. Equatorial, with the Meridian Circle and Meridian Photometer, together with the attendant reductions; and in the distribution of time-signals over the greater part of New England.

With the large equatorial, many important observations upon the satellites of Mars were made during the opposition of that planet. Employing the method of reducing the light of the planet, by colored glass (a method first used at this Observatory), the number of observed position angles of Deimos was 825; of Phobos, 278; and that of observed distances, 248. The probable errors of one setting were respectively 0.6°, 0.9° and 0.6". Besides the micrometric work, many photometric observations were made, the results of which indicate that if we assume the satellites to have a capacity for reflecting sunlight equal to that of Mars itself, Deimos has a diameter of about six, and Phobos of about seven miles. The photometric observations upon the eclipses of Jupiter's satellites give reason to believe that by this method the determination of longitudes may be made as accurately as by occultations or lunar culminations. Measurements of the light of planetary nebulæ have been continued. The spectra of nebulæ are also observed through a direct vision prism placed between the object glass and eye-piece of the telescope. The planetary nebulæ retain their shape under these circumstances, obviously indicating that their light is monochromatic. The difference between monochromatic objects and ordinary stars is so marked when thus examined, that a method of detecting small nebulæ was at once suggested, and a comparatively short search revealed three such objects. The most remarkable discovery, however, was in the spectrum of the star Oeltzen 17681, R.A. 18h. 1m. 17s., Dec. −21° 1', which shows that the light is concentrated in two points of the spectrum, one in the blue, the other in the yellow. A faint, continuous spectrum is also seen.

Between Sept. 24, 1879 and Nov. 1, 1880, observations were made with the Meridian Circle on 277 days, the work being confined to the determination of the absolute co-ordinates of 109 fundamental stars, in connection with which observations of the sun and of Polaris were made as often as possible. Up to Nov. 1, 1880, 183 observations of Polaris had been obtained, 131 of the Sun and 1760 of Fundamental Stars. To furnish the means of measuring the variation of the instrumental changes between one culmination of Polaris and the next, a collimator with focal length of 206 feet was constructed and has given excellent results.

A Meridian Photometer devised by Prof, Pickering has been used in continuing the measurement of the light of all stars visible to the naked eye between the north pole and the parallel of 30° south declination. Over 40,000 separate settings have already been made, and it is probable that the work will be completed in October next. The instrument, as its name implies, is mounted in the meridian and forms polarized images of the pole star and the star to be observed, which are brought to equality by turning a Nicol prism.

The time signals from the Observatory are distributed to the railroads and several prominent jewelers in Boston, and through the railroad companies to many of the neighboring towns. By the co-operation of the United States Signal Service Officer a time-ball is dropped in Boston at noon. The signals are also used in connection with those from the United States Naval Observatory, and the Allegheny City Observatory for the regulation of the New York time service.

During the past year, the second part of Volume XI of the Annals of the Observatory, containing a discussion of 25,000 photometric observations made with the great equatorial, and Volume XII containing the results of observations made by Prof. W. A. Rogers in 1874 and 1875 with the Meridian Circle have been completed and distributed, and six more volumes are in a more or less advanced state of preparation. W. C. W.

WASHINGTON, D. C.

ON THE THERMAL BALANCE.*

BY PROF. S. P. LANGLEY.

When the thermometer is not sufficiently sensitive for delicate investigation of radiant heat, scientific men have been accustomed, since the time of Melloni, to the use of the thermopile, an instrument which, employed in connection with the galvanometer, permits the making of numerous important measures. It has not been improved materially in the last fifty years. Meanwhile, many problems of both high theoretical and practical interest have arisen, which cannot be solved without a more sensitive and accurate instrument. One of these problems is the measurement of the distribution of radiant energy in a pure spectrum, when the rays have not passed through any prism. I could obtain no accurate results with the thermopile. I was forced to invent a more sensitive instrument for this special investigation, and, having done so, I believe it will be of general utility. The principle of the new apparatus has been applied by Dr. Siemens and others to other purposes. I spent several months in making it, as I hope, a useful working tool for the physicist and the physical astronomer. It is founded on the principle that, if a wire conveying an electric current be heated, less electricity flows through it than before. If two such wires, carrying equal currents from a powerful battery, meet in a recording apparatus (the galvanometer) the index of the instrument—pushed in two opposite ways by exactly equal forces—will remain at rest. If one current be diminished by warming ever so little the wire that conveys it, the other current causes the index to swing with a force due, not directly to the feeble heat which warmed the wire, but to the power of the battery which this feeble heat controls.

The application of this principle is thus made: Iron or steel is rolled into sheets of extreme thinness. I have succeeded in rolling sheets of steel made at the works of Miller & Parkin, Pittsburg, Penn., until it took 8000 of them to make the thickness of an inch. Of the platina sheets rolled at the United States Mint in Philadelphia, fifty laid one on another do not together equal the thickness of light tissue paper. Minute strips of these, 1-32 of an inch wide and ¼ of an inch long, were united so as to form a prominent part of the circuit, through which a part of a powerful battery passed to the galvanometer. Experiment proves that an almost inconceivably minute warming of a set of these strips reduced the passage of the electricity so as to produce very large indications on the registering instrument. I have in the course of my experiments thus far, found iron the most advantageous, though other metals are still under trial. The instrument thus formed is from ten to thirty times more sensitive than the most delicate thermopile; but this is almost a secondary advantage compared with its great precision and the readiness with which it is used. The thermopile is very slow in its action. This new instrument, the thermal-balance, takes up the heat and parts with it again in a single second. It is almost as prompt as the human eye itself.

With reference to its accuracy, experiments prove that the probable error of a single measurement made

* Read before the National Academy of Sciences, N. Y., 1880

with the instrument can be reduced to within 1 per cent. of the amount to be measured. It will register a change in the temperature of the strips just described, not exceeding 1-50,000 part of a Fahrenheit degree. When mounted in a reflecting telescope it will record the heat from the body of a man or other animal in an adjoining field, and can do so at great distances. It will do this equally well in the night, and may be said, in a certain sense, to give the power of seeing in the dark. A more valuable proof of its efficiency is shown in a series of measurements of the heat of the moon, made under varied circumstances, to guard against error, but each made in a few seconds. All these measurements show that the almost immeasurably minute amount of heat from the moon can be certainly measured by it, even with a common refracting telescope.

CORRESPONDENCE.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. No notice is taken of anonymous communications.*]

To the Editor of SCIENCE :—

In a recent issue of "SCIENCE," "B. G. W." in a very instructive review of Marsh's monograph on the limbs of the *Sauranodon*, speaks of Darwin's hypothesis regarding *sexdigitism* in man, as reluctantly abandoned by that evolutionist, but as now standing some chances of rehabilitation owing to the discovery of *sexdigitism* as a normal feature of the extinct genus *Sauranodon.* Probably the reviewer has not met with a treatise, in in which a certain discovery of an embryonic peculiarity is detailed, and which explains not only the occurrence of *sexdigitism* but of *polydactylism* in man. As this treatise is in the hands of few comparative anatomists, I may refer to the facts here at some length. In figure 76 on page 137 of Schenk's *Lehrbuch der vergl. Embryologie der Wirbelthiere* (Vienna, 1874), is represented a section taken flatwise through the embryonic human paw. The chondrogenic elements of the mesoblast can be seen arranged in strands, indicating the metacarpophalangeal rays. A sixth ray seems very clearly present, and from some of the other rays lateral processes spring, which in the course of normal development become merged into the main ray, no doubt.

On this head, as well as some others related to the temporary presence of ancestral features in the ex remities of the human embryo, I have written as follows in a series of lessons on embryology, published in the *St. Louis Clinical Record:*

At the points where the head and tail were respectively deflected from the trunk the peripheral protovertebrol masses are bulged out, as it were, and thus we have twa anterior and two posterior ill-marked eminences composed of mesoblast elements covered by the cutaneous epiblast. These are the anterior and posterior extremities. The posterior pair is the earliest to be discovered, but it is so rapidly outstripped in growth and development by the anterior extremities, that the belief has become current that the anterior are the first to appear, which is incorrect.

At the time when the hand has become demarcated from the forearm by the wrist constriction, the forearm has not yet become separated from the arm. And in like manner the foot is individualized before the leg and thigh are demarcated. The fingers are developed before the toes, and in both the hand and foot the digital segmentation is preceded by a stage in which there is a fold formed separating a main mass from the aggregate digital mass, and which persists in the adult.

If a surface section be made of an embryonic hand or foot before the digits are formed, we will find that the cell-strands which constitute the basis for each metacarpo-phalangeal ray are not five, as in the adult and developed fœtus, but are from seven to nine (at different periods) in number. This remarkable fact, discovered by my teacher, Prof. Schenk, of Vienna, points, in a manner, to the descent of the pentadactylous animals, to which man belongs, from the enaliosaurians or analogous groups of the jurassic and triassic periods of the earth's history whose fossilized remnants clearly show that they had seven or more fin rays.

To many, another and related fact will prove still more convincing in an evolutional point of view, although Schenk's observation is of more fundamental importance than the following to zoötomists:

Hensen, of Kiel, discovered that, in a *human* embryo of the seventh week, *the fingers and toes are provided with claw-like appendages like the claws of carnivora,* and that these structures are exfoliated to make way for the true nails. Further, he found plantar and palmar eminences like the *foot-pads of the dog, cat and marsupial carnivores.** E. C. SPITZKA.

NEW YORK Jan. 7, 1881.

BOOKS RECEIVED.

WAS MAN CREATED? By HENRY A. MOTT, JR., PH. D. Griswold and Company, New York.

The time is still distant when conclusions will be drawn on the subject of the Origin of Man and many other problems treated by the author of this book. Material is accumulating faster than it can be arranged, but in all probability, a thousand years hence we shall still be without sufficient data and be diligently searching for evidence.

The scientific man is not discouraged on this account, but is well content to work on, adding daily to the great store-house of knowledge, indifferent as to whether final results are arrived at in his own day or in the future.

There is, however, another class of persons in society, who, finding that certain scientific truths, which are undeniable, conflict with revealed religion, desire a more speedy solution of these questions.

Dr. Mott in his book attempts to outline a middle course for those who are forced by scientific discovery to renounce the Biblical teachings respecting the Origin of Man, by showing from a large number of authorities, that a belief in the dual existence of man may be held upon reasonable testimony.

Had Dr. Mott called his book "An Introduction to the Study of the Origin of Man and his Future Destiny," we think it would have been an appropriate title, and would have commanded a large class of readers who are unable to obtain the larger works consulted by the author; and the seventy-five illustrations, which are well selected, would have been of considerable service to such persons in grasping the subject which is naturally complicated to those who approach it for the first time.

DR. IRVINE, of Glasgow, recently exhibited and explained before the Mining Institute of Scotland, his new safety-lamp, which is constructed to emit a loud sound when an explosive mixture of gas and air enters it, and thus consequently indicates fire damp in colleries.

* Development of the Human Ovum Embryo, and Fœtus, *St. Louis Clinical Record*, (Lecture VIII.) June, 1880.